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MINI-REVIEW

Coronary artery revascularization in hemodialysis patients with multivessel coronary artery disease

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Summary Coronary artery disease (CAD) is a major cause of morbidity and mortality in patients with end-stage renal disease (ESRD). Such a combination poses a considerable technical challenge for revascularization because of multiple comorbidities and higher surgical risk. Here, we conducted a literature review on different revascularization strategies, on-pump and off-pump bypass grafting outcomes, harvested internal mammary artery numbers, and potential complications (e.g., steal syndrome) in managing patients with ESRD and comorbid CAD.

1. Introduction

Coronary artery disease (CAD) is a major cause of morbidity and mortality in patients with end-stage renal disease (ESRD). Despite the development of revascularization therapies and refinement of surgical techniques in past decades, the prognosis of patients with ESRD remains poor; the estimated 5-year survival rate after dialysis initiation is only approximately 34%.[1] The most crucial cause of mortality in these patients is cardiac disease, accounting for 39–45% of all deaths.[2,3] Compared with nondialysis patients, patients with ESRD are more likely to have CAD, and most cases are symptomatic multivessel CAD. Moreover, the prevalence and incidence of ESRD are high in Taiwan. Therefore, we conducted this review to determine the survival outcomes and risk factors for mortality following coronary artery bypass grafting (CABG) surgery.

Conflicts of interest: All contributing authors declare no conflicts of interest.

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2. Revascularization: percutaneous coronary intervention versus CABG

The most appropriate method for revascularization is debatable. To date, the optimal treatment for cardiac disease in patients with ESRD remains unknown. According to our research, no randomized controlled trial specifically addressing this debate has been reported. A previous study suggested using CABG over percutaneous coronary intervention (PCI) for complete revascularization because CABG has an extensive atherosclerotic nature and provides a higher chance for renal transplantation in the future.[4] However, in recent decades, the use of PCI has increased,[1] despite evidence of more favorable long-term outcomes in patients with ESRD after CABG compared with those in these patients after medical management or PCI. In other words, an increasing number of patients with ESRD and stable multivessel CAD have undergone PCI as a treatment option. With advancements in technology, a decreased risk of complications and a higher success rate can be achieved, which is crucial given the foreseeable need for repeat revascularization.

Advancements in CABG surgery have lowered operative morbidity and mortality rates. In addition, cardiac surgery has become considerably safer for patients with ESRD in recent years; however, their overall prognosis remains poor.[1] The perioperative risks involved in cardiac surgery are higher in patients with ESRD than in the general cardiac patient population, possibly because of multiple extracardiac comorbidities such as ventricular hypertrophy, cerebrovascular and peripheral artery disease, infection, electrolyte disturbance, anemia, cachexia, and increased oxidative stress.[5] Ko et al[6] reported an overall mortality rate of 9% in 296 patients with ESRD who underwent cardiopulmonary bypass (CPB) procedures. According to the American College of Cardiology and American Heart Association guidelines, CABG can be performed in select dialysis patients, with an increased but acceptable risk of perioperative morbidity and mortality.

3. Off-pump CABG versus on-pump CABG

The increased operative risk in ESRD patients undergoing cardiac surgery is mostly due to preexisting multisystem diseases, generalized atherosclerosis, heavily calcified aorta and coronary arteries, complicated intraoperative and postoperative management, and bleeding tendency. Off-pump coronary artery bypass (OPCAB) seems intuitively simpler and less invasive for hemodialysis (HD)-dependent patients. Manabe et al[7] suggested a physiological basis for supporting OPCAB in HD patients; they reported an improvement in cardiac hemodynamics in terms of a postoperative decrease in the right atrial and pulmonary capillary wedge pressure and postoperative lung oxygenation in patients who underwent OPCAB compared with those who underwent on-pump CABG. Moreover, the application of newly developed surgical equipment, such as stabilizers, has facilitated coronary anastomoses on the beating heart, thus avoiding the need for CPB surgery and preventing subsequent inflammatory responses, fluid overload, electrolyte imbalance, and aggravated bleeding disorders in patients with uremia. In addition, with less manipulation of the ascending aorta, postoperative neurological complications might be decreased.

Although patients who have undergone revascularization through CPB demonstrated a marked increase in operative mortality compared with patients who have undergone OPCAB, the improved perioperative mortality did not show equivalent or more favorable survival in the long-term follow-up.[8] A study investigated the shorter longevity in OPCAB patients who survived the perioperative period (Figure 1).[8] In addition, using data from the United States Renal Data System database in a comorbidity-adjusted Cox model, Beckermann et al[9] investigated 3922 patients who underwent either OPCAB or on-pump CAB. They reported an association of OPCAB with morbidity benefits and a 16% decrease in all-cause mortality.

Several institutional reports have indicated that the off-pump technique provides a significant reduction in the morbidity associated with CABG. In a larger study, Shroff et al[10] enrolled 13,085 dialysis patients undergoing first CABG surgery and observed a considerable improvement early after OPCAB. Therefore, we believe that fewer grafts and incomplete revascularization are the key drawbacks in off-pump patients, due to technical challenges. Long-term survival is significantly more favorable in on-pump patients, possibly because of incomplete revascularization.

In our institution, OPCAB is not a risk factor for late death. We believe that even in dialysis patients, revascularization can be performed using the off-pump approach with high anastomosis quality.[11] In conclusion, compared with conventional CPB surgery, off-pump revascularization may provide superior perioperative morbidity and mortality in dialysis patients.

4. Single internal mammary artery versus bilateral internal mammary artery versus saphenous vein graft only: Long-term survival

Internal mammary artery (IMA) grafts provide superior benefits compared with other CABG grafts. IMA grafting for

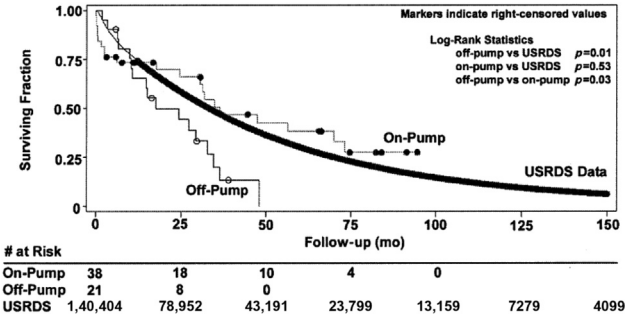

Figure 1 End-stage renal disease Kaplan—Meier survival curve for patients without diabetes. Patients revascularized with cardiopulmonary bypass have a long-term survival advantage; the on-pump data lie above the United States Renal Data System (USRDS) curve at all points.
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lesions of the left anterior descending (LAD) coronary artery is preferable whenever indicated and technically feasible.[12] In patients requiring long-term dialysis, the benefit of IMA grafting is more notable because of the high resistance of the IMA to atherosclerosis, intimal hyperplasia, and medial calcification.[13]

Although dialysis patients often have calcification in their coronary arteries, aorta, and other peripheral arteries, chronic renal failure has a minimum effect on atherosclerotic changes in the IMA. Furthermore, in 170 dialysis patients who underwent CABG, Hsu et al[14] reported an acceptable operative mortality rate of 8.2%, which was more satisfactory than that in the natural course of dialysis-dependent patients with renal failure. In addition, they reported that the use of the left IMA graft was a significant predictor of operative or long-term mortality. Most late deaths were due to infection or cardiac events. In a retrospective study, Bechtel et al[15] reported that using an IMA graft, having sinus rhythm, and undergoing renal transplantation were associated with longer survival in patients with ESRD undergoing CABG.

The use of bilateral IMA (BIMA) in dialysis patients is controversial. Because of poor wound healing and increased bleeding following IMA grafting, this technique was previously assumed to be ruled out in renal dialysis patients. Some studies[13,16] have reported significantly more favorable long-term results in terms of cardiac-related events and freedom from cardiac mortality in BIMA patients, at the expense of greater chest tube drainage volume or possibly larger blood transfusions.[16] Therefore, harvesting the IMA in a skeletonized manner is preferred to prevent mediastinitis, particularly in patients with ESRD.

5. Steal syndrome

Another concern is the effect of the *in situ* IMA graft ipsilateral to the arteriovenous (AV) fistula on outcomes following CABG in dialysis-dependent patients. Successful revascularization of the LAD is always considered as the key factor for clinical outcomes in patients with ESRD and in nondialysis patients. *In situ* harvesting of the left IMA (LIMA) decreases the manipulation of the atherosclerotic ascending aorta, which is a potential source of systemic emboli after proximal anastomosis.

However, a risk of coronary steal persists, which may lead to a dynamic decrease of the ipsilateral IMA flow as a potential cause of poor outcomes in patients with ESRD following CABG. Gaudino et al[17] observed a hemodynamically evident *in situ* LIMA flow steal and consequent myocardial hypokinesia on transthoracic echocardiography during HD in five patients with ipsilateral AV fistula and IMA graft. Possible risk factors include altered IMA anatomy, subclavian stenosis, anatomical AV fistula location, and progressively increased blood flow through the AV fistula with time.

By contrast, several studies[5,18] have reported no significant changes in survival (Figure 2) or Doppler flow of the ipsilateral or contralateral IMA with the occluded AV fistula during HD. A poorer prognosis in dialysis patients undergoing CABG is associated with more diffuse CAD with poor runoff but not with the side of the IMA graft and the LAD steal on the same side as the AV fistula. Compared with the contralateral group, revascularization did not increase operative mortality or risks of late death and cardiac events after isolated CABG in dialysis patients. We do not generally use the ipsilateral IMA if patients undergoing HD have a high flow through the AV fistula.

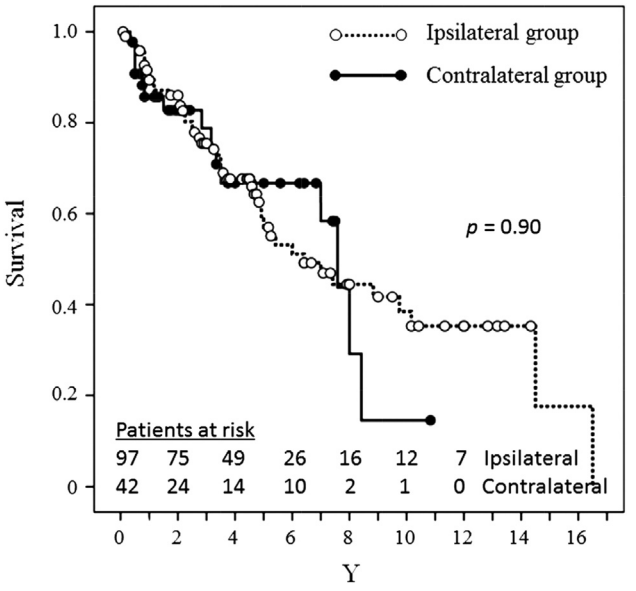

Figure 2 Estimated freedom from major adverse cardiac events in the Kaplan—Meier model for patients whose left anterior descending (LAD) artery was revascularized with the internal thoracic artery (ITA) ipsilateral to the arteriovenous fistula (ipsilateral group, dotted line) and for patients whose LAD artery was grafted with the ITA opposite to the fistula (contralateral group, solid line). *Note*. From "Effects of the side of arteriovenous fistula on outcomes after coronary artery bypass surgery in hemodialysis-dependent patients," by Y. Takami, K. Tajima, W. Kato, et al., 2014, *J Thorac Cardiovasc Surg, 147*, p. 619—624.

6. Conclusions and future research directions

Appropriate treatment decisions can be made for managing cardiovascular disease in the general population. However, making evidence-based decisions for the management of patients with concurrent renal disease is difficult. The potential long-term benefits of CABG may differ in patients with ESRD compared with the general population, and the perioperative risk of death may be unacceptably high. Nonetheless, CABG has long been the dominant revascularization strategy in selected patients in our institute for multivessel diseases. Additional research will raise the awareness of surgeons for making appropriate patient-related decisions regarding coronary artery revascularization.

References

1. US Renal Data System (USRDS). *USRDS 2005 Annual Data Report: Atlas of End-Stage Renal Disease in the United States*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2005. Available from: http://www.usrds.org/atlas_2005.htm [Last accessed: March 15, 2016].
2. Frei U, Schober-Halstenberg HJ. *Nierenersatztherapie in Deutschland. Bericht Über Dialysebehandlung und Nierentransplantation in Deutschland 2003/2004*. Berlin, Germany: Quasi-Niere gGmbH; 2004. Available from: http://www.quasiniere.de/berichte/online/de/03/world.htm [Last accessed: March 15, 2016]. [Article in German].
3. US Renal Data System (USRDS). *USRDS 2004 Annual Data Report: Atlas of End-Stage Renal Disease in the United States*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2004. Available from: http://www.usrds.org/atlas_2004.htm [Last accessed: March 15, 2016].
4. de Lemos JA, Hillis LD. Diagnosis and management of coronary artery disease in patients with end-stage renal disease on hemodialysis. *J Am Soc Nephrol*. 1996;7:2044—2054.
5. Takami Y, Tajima K, Kato W, et al. Effects of the side of arteriovenous fistula on outcomes after coronary artery bypass surgery in hemodialysis-dependent patients. *J Thorac Cardiovasc Surg*. 2014;147:619—624.
6. Ko W, Kreiger KH, Isom OW. Cardiopulmonary bypass procedures in dialysis patients. *Ann Thorac Surg*. 1993;55:677—684.
7. Manabe S, Arai H, Tanaka H, Tabuchi N, Sunamori M. Physiological comparison of off-pump and on-pump coronary artery bypass grafting in patients on chronic hemodialysis. *Jpn J Thorac Cardiovasc Surg*. 2006;54:3—10.
8. Dewey TM, Herbert MA, Prince SL, et al. Does coronary artery bypass graft surgery improve survival among patients with end-stage renal disease? *Ann Thorac Surg*. 2006;81:591—598.
9. Beckermann J, Van Camp J, Li S, Wahl SK, Collins A, Herzog CA. On-pump versus off-pump coronary surgery outcomes in patients requiring dialysis: perspectives from a single center and the United States experience. *J Thorac Cardiovasc Surg*. 2006;131:1261—1266.
10. Shroff GR, Li S, Herzog CA. Survival of patients on dialysis having off-pump versus on-pump coronary artery bypass surgery in the United States. *J Thorac Cardiovasc Surg*. 2010;139:1333—1338.
11. Hsu RB, Lin CH. Surgical proficiency and quality indicators in off-pump coronary artery bypass. *Ann Thorac Surg*. 2013;96:2069—2074.
12. Loop FD, Lytle BW, Cosgrove DM, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. *N Engl J Med*. 1986;314:1—6.
13. Kai M, Okabayashi H, Hanyu M, et al. Long-term results of bilateral internal thoracic artery grafting in dialysis patients. *Ann Thorac Surg*. 2007;83:1666—1671.
14. Hsu HL, Hsu HP, Yu BF, et al. Long-term results of coronary artery bypass grafting in patients with dialysis-dependent renal failure. *J Cardiovasc Surg (Torino)*. 2015;56:809—816.
15. Bechtel JF, Detter C, Fischlein T, et al. Cardiac surgery in patients on dialysis: decreased 30-day mortality, unchanged overall survival. *Ann Thorac Surg*. 2008;85:147—153.
16. Nakayama Y, Sakata R, Ura M. Bilateral internal thoracic artery use for dialysis patients: does it increase operative risk? *Ann Thorac Surg*. 2001;71:783—787.
17. Gaudino M, Serricchio M, Luciani N, et al. Risks of using internal thoracic artery grafts in patients in chronic hemodialysis via upper extremity arteriovenous fistula. *Circulation*. 2003;107:2653—2655.
18. Rahbar R, McGee WR, Birdas TJ, Muluk S, Magovern J, Maher T. Upper extremity arteriovenous fistulas induce modest hemodynamic effect on the *in situ* internal thoracic artery. *Ann Thorac Surg*. 2006;81:145—147.